Plant Adaptation

Adaptation consists of heritable modifications in structures or functions that increase the probability of an organism surviving and reproducing in a particular environment.

Light variations and adaptation plants to light variation

The intensity and spectral quality of light exhibits large temporal and spatial variation. The spectral quality of light, available for plants in the shade environment, is often different from that of the full sun light due to filtering by the canopy. Plants are also frequently exposed to rapid and irregular changes in light intensity, which could be caused by clouds and sudden shading by other plants and, diurnal changes in light quality. During the evolution plants have developed many adaptation mechanisms to cope with fluctuations in the light environment. These can be divided into two major groups:

A—adaptations to control light absorption capacity and
B—adaptations to deal with the light energy, which has been captured.

Adaptations:

In plants growing under high light intensity leaf surface area may be greatly reduced to decrease light absorption. Leaves become scale like or needle like or they may be rolled or folded.

Plants adjust leaf orientation; this helps plants to cope with changes in irradiation. Leaf movements can be of developmental (slow and irreversible), passive (drought related) and active nature (reversible). This adaptation is very effective in shade, which are occasionally exposed to light bursts.

Some xerophytes have developed a number of adaptations to increase leaf reflectance and therefore reduce the amount of absorbed light. The adaptations may include building up inorganic deposits on the leaf surface (for example, salt crystals) or epidermal hairs.

On the cellular level, light absorption can be regulated by chloroplast movements.

A most profound type of plant adaptation to light occurs at the molecular level. The regulation of light absorption occurs by long-term control of chlorophyll content in
leaves. The short-term adaptations of the photosynthetic membrane include changes in Light harvesting antenna complex size and efficiency.

In plants, grown under high light intensity the Light harvesting antenna complex is always smaller than in those grown in shade.

The shade plants grown under the forest canopy possess a higher PSII/PSI ratio to compensate for the reduction in the amount of red light.

**Photoinhibition:** In high light the build-up of the excess excitation energy in antenna systems will inevitably lead to photoinhibition, a sustained decline in the photosynthetic efficiency and productivity, associated with the damage of photosynthetic reaction centers.

**Photoperiodism:** It is the influence of daylength on growth and development. The relative duration of light and dark period changes with latitudes. At equator the night and day are of equal length through the year but at higher latitudes day length increase during summer and decreases during winter. These changes in light period duration regulates plant development and growth process i.e. flowering, shedding of leaves, degree of branching, rate of growth.

**Temperature variations and adaptation plants to temperature variation**

Temperature has a very profound effect on plant metabolism, growth and development. Temperature affects chemical reactions, gas solubility, mineral absorption, transpiration, assimilation, respiration, growth and seed germination of plants. When rainfall remains uniform change in temperature changes the flora of the area. Schimper’s first law states “while the general type of vegetation is not related to temperature the type of flora of a particular region is determined by it.”

**Adaptation**

Plants adapted to hot, bright and fairly dry climates by evolving Kranz anatomy and C4 photosynthesis.

Photosynthesis and respiration are differently affected by transpiration changes. The temperature at which rate of photosynthesis is equal to the rate of respiration is called compensation point.

There is a direct relationship between temperature and transpiration. At higher
temperatures plant body is adapted to reduce surface area and to minimize transpiration. Stem and leaves are reduced, become succulent, and have a tough, multilayered outer or covered with hairs or resins. Number of stomata are greatly reduced are covered with hairs or become sunken. Roots are well developed.

Plants called ephemerals have adapted to avoid dry and hot conditions. They grow actively in wet season and complete their lifecycle within a short span of time. Then they reproduce and produce seeds that are highly resistant to aridity and heat. These seeds remain dormant through-out hot and dry season and germinate only when favourable conditions for growth return.

In plants that grow in areas where temperature in winters is very low undergo a cycle of hardening before winter and dehardening before summer to prevent cold or frost injury. During autumn, leaves are shed; growth rate is reduced; plants become dormant in winters; metabolites are produced to reduce crystal formation inside cells; increase in polyunsaturated fatty acids in cell membrane.

Plants have adapted to avoid very cold temperatures, they grow actively in warm conditions but when exposed to lower temperature they flower and produce seeds, this process is called vernalization. The seeds remain dormant through-out winter and germinate only when favourable conditions for growth return in spring.

Food Chain

The transfer of food energy from its source in plants through herbivores to carnivores to detritivores or decomposers is referred to as the food chain. So, the food chain is primarily concerned with the transfer of food energy.

Sun provides energy to the plants and that energy is stored in the carbohydrates in different organic molecules, the energy from sunlight is converted into chemical energy; and this chemical energy moves through different organisms in a community in the form of the food chain.

Autotrophs

Autotrophs are organisms responsible for primary production. Also known as primary producers; they include trees, plants and algae.

Now autotrophs are divided into photoautotrophs and chemoautotrophs.
**Photoautotrophs**

Photoautotrophs are organisms that use light as a source of energy to manufacture organic molecules and food; example most plants.

**Chemoautotrophs**

Chemoautotrophs are organisms that use chemical reactions as a source of energy to manufacture organic molecules and food.

**Heterotrophs**

Heterotrophs are organisms that cannot produce their own food. They rely instead on the intake of nutrition from other sources of organic carbon mainly plant or animal matter and example includes most animals.

When we talk about food chains we can divide all the organisms into producers and consumers. Producers is an organisms that makes their own food i.e they are autotroph; including the photoautotrophs and the chemoautotrophs.

**Consumers** are organisms that consume some other organism or some part of other organism for food. The consumers are further divided into primary, secondary, tertiary and quaternary consumers.

**Primary consumer** is an organism that consumes the producers. That is the an organism that consumes the plant matter or the autotrophs. Example: a grasshopper or a cow or all the herbivorous animals, most of these organisms are very important prey species in the ecosystem.

The primary consumers are eaten up by their predators which go by the name of **secondary consumers**. So, primary consumer is a herbivore and secondary consumer is a carnivore. It could also be an omnivore which feeds on the plants and animals. Example: a frog.

So, we have the producer, that is eaten up by the primary consumer, which is then eaten up by the secondary consumer, which is then eaten up by the tertiary consumer, which is then eaten up by the quaternary consumer and so on.

**Tertiary consumer** is an organism that eats a secondary consumer. example: a snake.

A **quaternary consumer** is an organism that consumes the tertiary consumer such as
the hawk.

**Omnivore** is an organism that eats both plants and animals and they are generally secondary or tertiary consumers example is the bear. The bear can eat some insects, it can also eat some amount of flesh, but it also feeds on fruits, on roots of plants and so on; so, it is an omnivorous.

A **decomposer** is an organism that converts dead material into soil and recycles the nutrients. When we are talking about any food chain not only is energy is passed, but also other nutrients such as minerals. For instance when we talk about proteins, proteins have nitrogen in them. The plant proteins have nitrogen, from there the nitrogen moves into the grasshopper, from there to the frog, from there to the snake, from there to the hawk and eagle. But then, if all the nutrients and the inorganic materials get locked up the organisms, the plants will not be able to get them. So, here in comes the role of the decomposers. The decomposers break up the organic materials present excretory products and dead plant and animal bodies and release all of these nutrients back into the soil.

So, decomposer is an organism that converts dead material into soil and recycles nutrient. Decomposers include detritivores and microorganisms.

Food chains are of two kinds; one is the grazing food chain and the second one is the detritus food chain. The grazing food chain starts from the plant base and goes through herbivores to carnivores. The grazing food chains further subdivided into predator food chains and parasitic food chains.

On the other hand a detritus food chain starts from the detritus or the dead and decaying matter and then it goes through detritivores to carnivores.

So, essentially in the case of the grazing food chain we have plants followed by herbivores followed by carnivores, and these carnivores can be secondary, tertiary, quaternary and so on. In the case of detritus food chain we have detritus followed by detritivores and then these are followed by the carnivores; which can again be secondary, tertiary, quaternary, and so on.

Example

**Predator Food Chain**

Grass \( \rightarrow \) grasshopper \( \rightarrow \) frog \( \rightarrow \) snake \( \rightarrow \) hawk
Parasitic Food Chain

Rat (flea)(parasitic protozoa)

In a predator food chain the size of the organisms generally increases as we move up the chain.

On the other hand when we look at the parasitic food chains the size of the organisms generally decreases as we move up the chain.

Detritus food chain

Fallen leaves of mangroves (detritivores) (insect larvae)(small fish)(large fish)(piscivorous birds)

Now, if you look at the differences between both of these food chains we observe that: in the case of a grazing food chain the primary source of energy is the sun, which is then used up by the plants. In the case of the detritus food chain the primary source of energy is detritus or organic matter.

The length of grazing food chain is generally longer, and the length of a detritus food chain is generally shorter.

Plants have energy stored in their body tissues, when herbivores eat plants those they extract energy from plant and spend quite a lot of energy to warm up their bodies, to ensure that the blood circulation goes on, for the movement of their bodies and, only about 10 percent of that energy will get stored in the bodies of the herbivores. Again from herbivores to carnivores only 10 % will be stored. So, as we move up the food chain lesser is the amount of energy that is available.

In case of a grazing food chain, because it starts with the sun, so you ample amount of energy is available in the grazing food chain and so it can support longer chains. Whereas, in the case of detritus food chain because the starting material itself is very small it does not have a huge amount of energy. So, it cannot support a very long chain of organisms. So, a detritus food chain is generally shorter in length.

**Food Web**

In the nature isolated food chain is present, but multiple chains are present which are interlinked with each other to makeup a food web.
Grass (grasshopper (frog (snake (hawk

Caterpillar (bird)

So, a combination of different food chains that works together goes by the name of a food web. A food web is a system of interlocking and interdependent food chains.

A **trophic level** is each of several hierarchical levels in an ecosystem consisting of organisms sharing the same function in the food chain and the same nutritional relationship to the primary source of energy.

So, when we look at above food web, we have grass we may also have some trees, or some shrubs, or some herbs and so on. All of these organisms share the same function in the food chain that is all of them are producers, and the same nutritional relationship to the primary sources of energy, all of these are using the energy of the sun and then passing it on to the primary consumers or the herbivores. So, all of these according to above definition, together will form a trophic level.

Similarly all the organisms that feed on plants such as grasshopper, the caterpillars, deer, goat etc form another trophic level.

It is also possible that one organism may be part of several different trophic levels. For instance if a bird eats a caterpillars, caterpillar is the primary consumer, so the bird becomes a secondary consumer; but again if this bird eats a frog, in this case the frog is a secondary consumer; so, here the bird will also become a tertiary consumer; or if this bird eats some fruits from the trees, it will also become a primary consumer.

So, essentially any organism in a food web may occupy more than one of those trophic levels. So now, we can understand the level of complexity that is involved here. There are so many relationships and every organism or many organisms can occupy different trophic levels at the same time. So, to reduce this complexity we make use of some tools, and one such tool goes by the name of an ecological pyramid. An ecological pyramid is a graphical representation designed to show the biomass, numbers or energy at each trophic level in a given ecosystem. Biomass is the total amount of mass that is formed out of the biological entities that are present at each trophic level, or the number of organisms that are there at each trophic level or the energy that is there in each trophic level, these ecological pyramids have different names such as trophic pyramid, eltonian pyramid, energy pyramid, food pyramid and so on.
**Pyramid of Numbers**

A pyramid of numbers shows you the number of organisms that are present at each trophic level.

In the case of the first trophic level which is the plants or the producers, one can into the field and count how many plants are there; then we total up all of them all the trees, all the herbs, all the shrubs, all the grasses that are there together will come up with a number. And this number will be depicted by this particular portion of the pyramid. The area of this pyramid or the area of a particular block is proportional to the number of entities that we have at this trophic level and each of these different slabs show different trophic levels. So, this pyramid will show us the number of individuals that we have at each trophic level. Generally the number of individuals go down as we move up the trophic level for predatory food chain and is inverted in case of parasitic food chain.

**Pyramid of Energy**

In case of pyramid of energy we look at the energy that is contained in organisms at each trophic level. This pyramid is flatter or wider at the bottom and goes on tapering to the top. The amount of energy that is present at each trophic level goes on decreasing as we move up the food chain of the food web. Hence the pyramid of energy is always upright.

**Pyramid of Biomass**
In case of pyramid of biomass, the biomass of organisms that are present at each trophic level are considered. Generally it wider at the bottom and it goes on tapering as we move to the top. But it may also be inverted.

**Standing Crop**

A standing crop is the total dried biomass of the living organisms that are present at each trophic level. For instance in the grazing food chain the total amount of dried biomass that was present in the grasses is the standing crop for producers of this food chain.

**Ecological efficiency**

Ecological efficiency is the efficiency with which energy is transferred from one trophic level to the next.

In the case of ecological efficiency we are asking the question; when energy is being transferred from one trophic level to the next how much amount of energy is getting transferred and how much amount of energy is getting lost.

Now why do we see a loss of energy?

Because all the food that an organism eats is not used to increase biomass part of it is used as energy for movement and maintenance of body functions such as circulation, respiration etc and part of it is released as heat. This energy that is not fixed into biomass cannot be transferred to next tropic level.

**Symbiosis**

Interaction between two different organisms living in close physical association, typically to the advantage of both.

**Parasitism**

An association between two different organisms where one gains benefits at the expense of other.

**Commensalism**

An association between two different organisms in which one benefits and the other derives neither benefit nor harm.